Woodstock. HULL.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

THE GEOLOGY OF THE

COUNTRY AROUND WOODSTOCK, OXFORDSHIRE.

(SHEET No. 45 S.W.)

BY

EDWARD HULL, A.B., F.G.S.

LISTS OF FOSSILS, BY R. ETHERIDGE, F.G.S., F.R.S.E.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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1859.

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NOTICE.

THE following Memoir, by Mr. E. Hull, descriptive of the Geological Structure of the Country around Woodstock, in Oxfordshire, is highly interesting to men of science in showing the great extent to which the Oolitic subformations of the Cotteswold Hills, near Cheltenham, thin out in their prolongation to the south-east, whilst the Proprietary will learn with satisfaction that the Blenheim iron ore occupies the same place in the Lias deposits as the valuable iron ore of the Cleveland Hills in Yorkshire.

RODERICK I. MURCHISON,
Director-General.

THE Country around Woodstock, to which this Memoir refers, was mapped entirely by Mr. Hull in the years 1857 and 1858. I examined the entire district with him both during and after its completion, and I can answer for the general correctness of the lines.

A. C. RAMSAY,
Local Director for Great Britain.

Geological Survey Office,
October 1859.

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PHYSICAL FEATURES.

THE physical features of this district are characteristic of the Oolitic rocks of England, and are similar to those of the neighbouring region of the Cotteswold Hills. The northern half, occupied by the Great Oolite and the subordinate formations, may be considered as an elevated plain sloping gently towards the south, and traversed by narrow valleys, with winding arms, which decrease in depth till they gradually disappear at the surface of the plain. That portion of the district bounded on the north by the valley of the Evenlode, as far as Bladon, and stretching thence to Kirklington Park, formed, for the most part, of Oxford Clay, is more diversified, and at Wychwood Forest and Wytham the country rises into hills, attaining at the latter place an elevation of 583 feet above the sea.*

The principal rivers are the Evenlode and Cherwell, both of which enter the Isis near Oxford. At its confluence the Evenlode is 237 feet above the sea, and the Cherwell a few feet lower.

The Evenlode has its sources in the vale of Moreton; and it is remarkable that its valley has been cut through the barrier formed by the Great Oolite, while, apparently, a little more denudation would have drained the waters into the vale of the Avon, which flows through a more northerly part of the same Liassic valley. The watershed, however, instead of following the outer ridge of the Oolite along the line of the Cotteswold promontory, crosses transversely the vale of Moreton from west to east, and the channel for the escape of the large quantities of water flowing from the surrounding hills has been cut through a part of the Oolitic barrier. Between Charlbury and Hanborough the channel, where it traverses the limestone of the Great Oolite, becomes narrow, and forms a succession of curves. At the outer side of the curve the bank assumes the form of a richly wooded cliff of semi-circular outline, while the opposite bank slopes

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* By the barometric observations accompanying the geological map of the late Rev. A. D. Stackpoole.

gradually down to the alluvial flat of the river. This form of valley is very common in the Oolitic districts of the Cotteswold Hills.

It is interesting to observe how the geology of the district has determined the sites of most of the villages. Thus, along the valley of the Evenlode, villages are planted wherever there are copious springs combined with a dry situation, circumstances generally to be found in the small lateral valleys which are excavated in the Oolite and Lias, and in these most of the villages are grouped. In other parts of the district similar advantages have determined the sites of Enstone, Kiddington, Glympton, Wooton, Woodstock, Bladon, Steeple Barton, &c. Some of these villages are, perhaps, as old as the Norman Conquest, and have not altered much in size through several centuries.*

Geological Formations.

The formations described in the Memoir are the following:—

Newer Pliocene - -	(Not coloured in Map).
Middle Oolite - -	Coral Rag. Lower Calcareous Grit. Oxford Clay.
Lower Oolite - - -	Cornbrash. Forest Marble. Great Oolite. Inferior Oolite.
Lias - - - - -	Upper Lias Clay. Marlstone. Lower Lias Clay.

A general section of nearly all the geological formations to be described is given in Fig. 5, p. 30. It has been drawn from the Evenlode to Leafield in Wychwood Forest, and shows at a glance the relative position and thickness of the different strata, and of the more recent high and low level gravels. An occasional reference to this diagram may be found of assistance to those who are not familiar with the subject in hand.

Adopting the ascending order, I will commence with the oldest formation in the district.

Lias.

Lower Lias.—This formation occupies but a small tract of the district, occurring only in the valley of the Evenlode as far down as Charlbury, and running along the base of the Oolitic ridge from Shipton to Sarsden, in which direction the ridge forms the limit of the vale of Moreton. During the excavations for

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* In some of the churches there still exist fragments of Anglo-Norman architecture, as at Woodstock and Witney, but most of those now standing were founded in the thirteenth and fourteenth centuries, and were subsequently rebuilt either in whole or in part in the fifteenth and sixteenth centuries, during the period of the "Perpendicular style."

the Oxford and Worcester Railway several sections were opened in the Lias, the principal of which are at Shipton Station, beyond the border of the sheet, and at Ascott within its edge. At this latter place the skeleton of an Ichthyosaurus was found underneath oolitic gravel, containing the bones and tusks of a fossil Elephant.* These cuttings are now concealed by grass, and except in a brick-pit on the north side of the valley opposite Ascott, there are no sections. The presence of the Lias at the base of the Marlstone is, however, easily ascertained by the clayey nature of the ground, the outburst of springs, and indications by the road-sides sufficient to enable the surveyor to trace his boundary lines, but not enough to afford a knowledge of the strata or their organic contents.

In the section at Ascott we have an example of the highest beds. They consist of bluish shales, weathering grey and brown, with small nodules of earthy limestone and iron-concretions.

The fossils of this formation will be found on referring to the descriptive Memoirs of Sheets 44 and 34.

Marlstone.—This formation, otherwise called "Middle Lias," consists of two parts, the lower being formed of soft variously coloured sands, shales, and iron nodules; and the upper, which I have called the "Rock-bed,"† consisting of calcareo-ferruginous sandstone, in which the several constituents vary in different localities, as does also the thickness of the bed itself. This rock-bed in some localities, as at Enslow, Rowsham, and especially at Fawler, near Stonesfield, becomes highly ferruginous, and attains a thickness of from 5 to 8 feet. Where it has not been exposed to atmospheric influences the original colour is deep olive green, which on exposure turns to yellowish ochre, consequent on the change of the carbonate of iron into peroxide. Under the lens the green rock is seen to be finely oolitic, and the fossils, which in this district are principally *Brachiopoda* (*Terebratula* and *Rhynchonella*), are local and gregarious, being frequently scarce, as at Charlbury, and in other places occurring in vast numbers, as at Rowsham.

In the road sections at Chadlington and Dean, Marlstone with other associated Liassic beds may frequently be seen. At West End a bed of blue clay occurs immediately under the "Rock-bed," and at Dean, Ammonites may be found in the road cuttings, *Ammonites annulatus* being very plentiful. In this district, as throughout the Cotteswold range, the "Rock-bed" is the chief repository of the organic remains of the formation.

In the lane leading from Fawler to Tapples Wood, on the west side of the railway, the following section is exposed to view, showing the strata in succession from the Great Oolite to the base of the Marlstone. The beds dip south-west at about 10°, but the cause of this high angle is not apparent.

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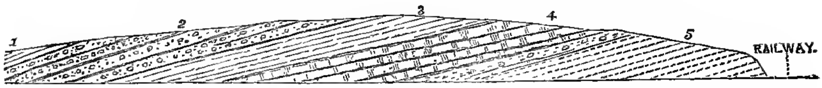
* This has already been stated by the author in the "Geology of the Country round Cheltenham," (Memoirs of the Geological Survey,) p. 92.

† Ibid., p. 18.

Fig. 1.

SECTION NEAR FAWLER.



1. *Great Oolite*	-	White shelly oolite (not well seen).
2. *Inferior Oolite*	-	Coarse rubbly oolite, 6 ft. thick.
3. *Upper Lias*	-	Grey shales and clays, 5 feet.
4. *Marlstone* rock-bed	-	*Iron ore*, 8 feet.
5. *Marlstone* sands	-	Fine sands, with balls of concretionary iron ore in the topmost bed, 15 feet.

The Marlstone Rock-bed may also be seen in the cuttings of the railway between Fawler and Charlbury, and is nearly 10 feet thick. At Enstone, the valley of the Glyme has been excavated into Marlstone, and in the roads which cross it there are several sections, especially at Woodford. In the roads on the right bank of the Cherwell, opposite Lower Heyford, there are several good sections, and here *Rhynchonella tetrahedra* occurs plentifully. In all these places the character of the subformation is similar, the rock-bed being essentially an iron ore, and resting on beds of sand, with bands of siliceous limestone. The thickness of the subformation is about 20 feet.

West of Charlbury the rock-bed is not so ferruginous as on the opposite side of the town, nor is its thickness so great; it is cut through by the railway in several places, and a section may be observed along the road which crosses the valley east of Shorthampton.

In many of the churches, old houses, and barns, blocks of Marlstone have been used with good effect in combination with the white oolitic limestone. When it has become weathered, it possesses a rich brown colour, which, when used in alternate courses or as corner stones, relieves the monotony of the oolite. To the advantage of colour it also adds that of durability, and has stood well in churches as old as the fourteenth century.

Fossils from the Marlstone (Fawler).

Belemnites elongatus, Mill.
Nerinæa.
Pecten ?
Ostrea.
Terebratula punctata, Sow.
Rhynchonella variabilis, Schloth.
R. tetrahedra, Sow.

Blenheim Iron Ore.—As this Marlstone rock-bed becomes, over a considerable area of this district, a valuable iron ore, the following additional particulars may be found useful.

Its outcrop along the valley of the Evenlode from Ashford Mill to Charlbury may be traced almost continuously. The average thickness of the bed is six feet, but it is sometimes more; it extends northward and southward of the valley, in the former case to the valley of the Cherwell, and in the latter to an unknown distance, but at least as far as the valley of the Windrush. When describing this formation in the neighbourhood of Burford, I have referred to its highly ferruginous character,* and since the assays of the Blenheim ore have determined its economic value, I feel disposed to think that the same bed at Burford will be found equally valuable. At Enstone the ore crops out in the valley, and as far as appearance is to be relied upon, there seems little difference between its qualities there and at the Evenlode valley. Further in the same direction at Steeple Aston the ore has already been smelted, and from the analysis, there appears to be little difference in its quality here and at Fawler.† All these facts tend to prove that the ore forms a continuous bed under the area of the Great Oolite between its outcrop in the valleys of the Cherwell and Evenlode, and with a dip of from $\frac{1}{2}°$ to 1° southward, in which direction it extends, the depth depending on the formation which composes the surface.

The appearance of the rock at the surface indicates its strongly ferruginous nature, but at some depth, where it has been protected from atmospheric influences, the ore is found to be of a deep green colour, and under the lens beautifully oolitic. In this state it is probably a silicate of iron,‡ which upon exposure changes into a hydrated peroxide of iron, with a variable percentage of carbonate of lime. Wherever it is most fossiliferous the proportion of lime is greatest, a fact to be observed when working the ore.

Nine specimens from the neighbourhood of Fawler have been assayed at the Museum of Practical Geology, and the following results, extracted from the report of Dr. Percy, have been placed at my disposal by the Duke of Marlborough.

Per-centage of Iron in each Specimen of Ore.

No.	1	contains of Metallic Iron	per cent.	38·65.
"	2	"	"	35·46.
"	3	"	"	37·14.
"	4	"	"	34·72.
"	5	"	"	32·52.
"	6	"	"	36·94.
"	7	"	"	31·40.
"	8	"	"	22·86.
"	9	"	"	13·06.

Nos. 8 and 9 contained fossils and a sensible (visible) amount of carbonate of lime.

* Geology of Cheltenham, p. 21.

† I have been kindly furnished with a copy of the analysis of the ore by W. Wing, Esq., of Steeple Aston.

‡ See also analyses of a similar ore, called the Cleveland ore, Yorkshire, by Mr. A. Dick. "The green colour of the ore seems to be due to a silicate containing peroxide and protoxide of iron, but this could not be exactly determined, &c."

Analysis of Average Sample.

(Obtained by mixing equal weights of all the specimens.)

Peroxide of Iron	44·67
Protoxide of Iron	0·86
Protoxide of Manganese	0·44
Lime	9·29
Magnesia	0·66
Alumina	7·85
Phosphoric Acid	0·55
Carbonic Acid	6·11
Silica (soluble in acid)	0·48
Sulphur	trace
Water	16·31
Residue insoluble in hydrochloric acid:—	
Silica	11·86
Alumina, with a trace of Peroxide of Iron	1·25
Lime	trace

Metallic Iron, per cent. 31·94; when calcined 41 per cent.

Dr. Percy remarks, "The phosphoric acid is present only in a small quantity, as compared with specimens of the Northamptonshire ores which have been examined in this laboratory. The absence of this ingredient is an important consideration for the iron smelter."*

Upper Lias Clay.—This formation consists of blue clay and shale, with occasional bands of argillaceous limestone, and it varies in thickness from about 40 feet in the neighbourhood of Sarsden to 8 feet at Fawler (see Fig. 1, p. 10); we may, therefore, believe that within the Woodstock district we probably reach the south-easterly limit of the Upper Lias.

Along the valley of the Evenlode and its branches the Upper Lias forms a narrow zone of moist ground producing springs; sections, however, are seldom seen. In some drainage trenches at Chadlington I found specimens of *Ammonites annulatus*, *A. serpentinus*, *A. communis*, and *Gresslya anglica* in a band of limestone near the base.

LOWER OOLITE.

Inferior Oolite.—This formation, which, at the western edge of the Cotteswold Hills, near Cheltenham, consists of several members, attaining a combined thickness of 264 feet, is represented in the Woodstock district by only the highest member of the series, containing a large Sea-urchin (*Clypeus Plotii*), which is found wherever these beds occur.

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* The Blenheim ore is identical with the Cleveland ore of Yorkshire in geological position, and contains *at least* as large a quantity of iron and less phosphorus. See Mr. A. Dick on the Cleveland iron ore, Quart. Journ. Geol. Soc. vol. xii. p. 357, and "Iron Ores of Great Britain," Mem. Geol. Survey, Part I. p. 45.

As in the case of the Upper Lias, this formation occurs in greatest strength at the north-western portion of the district, and from thence it thins away both towards the east and south. At Sarsden the thickness is about 20 feet; at Fawler, near Stonesfield, about 10 feet; at Enstone, only a trace; and along the valley of the Cherwell, it is altogether absent.

The lithological character of this subdivision is everywhere similar, and the beds are plentifully stored with their characteristic fossils. It may be described as a coarse-grained oolitic limestone of a yellow or brown colour, a loose friable texture, and very fossiliferous. Near the surface its breaks up into a rubble of rounded fragments, and from this character, as well as from the large size of the oolitic grains, it forms a contrast to the superincumbent beds of the Great Oolite which have a tendency to break up into slates and slabs.

The sections in the Inferior Oolite, though numerous, are seldom good, but the rock makes its appearance more or less clearly in all the roads which cross it along the valley of the Evenlode.

At Churchill,* along the road to Chipping Norton, there are several quarries, in which the rock is very fossiliferous, containing *Ammonites Murchisoniæ, Pholadomya* (two or three species), *Myacites, Lima gibbosa* (a characteristic fossil), *Pecten, Terebratula globata, Clypeus Plotii, Nucleolites clunicularis?* There is a quarry opened in Sarsden Park showing the lowest beds. In the sections along the roads on the north side of the valley opposite Ascott the same fossils occur plentifully. At Chadlington, a beautiful spring bursts out at its base, and springs rise in a similar position at Dean, Spilsbury, and Taston.

Along the base of the picturesque dell which runs far up into the heart of Wychwood Forest and along the side of Charlbury Park, the junction of the Upper Lias clay and the Inferior Oolite is indicated by copious springs and marshy ground. Small sections of the Oolite crop out occasionally with the usual fossils, especially at a bend in the valley called Buckleaf, where I found *Trigonia costata, Myacites, Terebratula globata, Anabacia* (an oval species). The stratum is very thin, and consists of large-grained rubbly oolite. Sections occur in the railway cuttings south of Charlbury, also at Fawler, and in the lane leading from Wilcote to Ashford Bridge, on the upthrow side of the fault. On the bank of the Evenlode, south of Stonesfield, a few square yards are brought to the surface by a fault; and the beds, which are of the usual character, and very fossiliferous, are well shown in a natural cliff. They dip south at about 6°, and are soon lost under the beds of the Great Oolite. This is the most easterly spot in the district where the Inferior Oolite reaches the surface.†

* Memorable as the birthplace of William Smith.

† Dr. Wright, of Cheltenham, informs me that the "Ragstone" is the principal representative of the Inferior Oolite on the Continent, the *Freestones* of Gloucestershire being for the most part inconstant strata, and chiefly developed in that county. The Ragstone is the "Zone des Ammonites Parkinsoni" of Oppel. See "Die Juraformation Englands, Frankreichs, und Deutchlands."

Having described the formations from the Lias to the Inferior Oolite inclusive, it is necessary that some observations should be made regarding their comparative insignificance in the neighbourhood of Woodstock.

The importance of these formations is not to be judged by their development along the valley of the Evenlode, because it is evident that, in the case of some of the beds at least, we have reached their easterly limits. But if we trace these formations westward to the flanks of the Cotteswold Hills in Gloucestershire, and compare the sections with those of the Woodstock district, we shall find that there is an enormous disparity both in the vertical thickness of the beds and in the fauna of both districts.* Taking the sections at Charlbury and Chadlington as points of comparison with that of Leckhampton Hill near Cheltenham, we find the following results:—

TABLE of COMPARATIVE SECTIONS.

CHELTENHAM.			CHARLBURY.		
Formation.	Subdivision.	Thickness in feet.	Formation.	Subdivision.	Thickness in feet.
Inferior Oolite, 264 feet.	*a* Ragstone - - *b* Upper Freestone - *c* Oolite Marl - - *d* Lower Freestone - *e* Pea Grit -	38 34 7 147 38	Inferior Oolite, 5 to 10 feet.	*a* Ragstone - - *b* Absent. *c* Absent. *d* Absent. *e* Absent.	5 to 10
Ammonite Sands.	*f* - - - - -	20 to 30	- -	*f* Absent.	
Upper Lias, 230 feet.	*g* Blue Shale - -	202	Upper Lias, 10 feet.	*g* - - - - -	10
Middle Lias or Marlstone, 116 feet.	*h* Rock Bed - - *h'* Sands - - -	6 110	Middle Lias or Marlstone, 16 feet.	*h* Rock Bed - - *h'* Sands - - -	6 10
Lower Lias.	Lower Lias Shale (about) - - Limestone - -	600	Lower Lias.	Thickness unknown.	

From the above comparison it will be observed, that all the strata included between the base of the Great Oolite and the top of the Lower Lias attain only a combined thickness of 30 or 36 feet at Charlbury, while at Cheltenham they reach 610 feet; and this is exclusive of the Fuller's Earth, an argillaceous formation between the Great and Inferior Oolites, which reaches 25 to 30 feet at Cheltenham, but is altogether absent in Oxfordshire.

Together with the attenuation of the strata there is also a corresponding diminution of the genera and species of fossils in the Woodstock district, as compared with that of Cheltenham. Many of the subdivisions of the Inferior Oolite and Lias contain, besides the species common to all, fossils which are exclusively confined

* See Geological Map, Sheet 44; also "Geology of the Country round Cheltenham" (Memoirs of the Geological Survey), Plate I., comparative vertical sections.

to each; and when these subdivisions disappear the characteristic shells disappear along with them. Hence, in the district of Woodstock, the fossils of the Inferior Oolite are those only which belong to the Clypeus Grit, or "Ragstone" subdivision, the only member which is constant over the whole area, and we have already seen that even this does not extend as far east as the valley of the Cherwell. The varied fauna of the Freestone, Oolite Marl, and Pea Grit* are all absent here, while even that of the Ragstone is considerably diminished. When we come to the Lias we miss the splendid group of Ammonites and Nautili of the "Cephalopoda bed."† The fossils of the Marlstone,‡ which are so abundant at Gretton, Dumbleton, and Bredon Hills, are scarcely represented in the Woodstock district, although the *Rock bed*, which in every place is the chief repository of the fossils, is fully developed. If, then, an observer were to derive his knowledge of the Inferior Oolite and Lias exclusively from the study of this district, it is evident that he would obtain a very imperfect idea of their importance, both in a stratigraphical and palæontological point of view; but if he traces these formations westward, he will find the beds themselves not only increasing in strength, but new subdivisions gradually appearing to swell the mass till it attains those proportions of thickness and organic richness which have rendered the Cotteswold Hills classic ground amongst geologists.

Fossils from the Inferior Oolite (Fawler).

Ammonites Parkinsoni? Sow.	*Trigonia costata*, Sow.
Littorina.	*Pholadomya ambigua*, Sow.
Modiola giobosa, Sow.	*Pecten lens*, Sow.
Homomya gibbosa.	*Terebratula perovalis*, Sow.
Isocardia.	*T. subglobosa.*
Goniomya, v. *scripta*, Goldf.	*Rhynchonella concinna*, Sow.
Myacites Jurassi, Brong.	

Fossils from Inferior Oolite (bank of the Evenlode, Stonesfield).

Nerinæa.	*Ostrea.*
Panopæa (cast).	*Terebratula maxillata?* Sow.
Isocardia.	*T. perovalis*, Sow.
Astarte (cast).	*Rhynchonella concinna*, Sow.
Cypricardia cordiiformis, Desh.	*Clypeus Plottii*, Klein.
Lima.	*Holectypus depressus*, Lam.
Pecten lens, Sow.	*Montlivaltia.*

Great Oolite.—This formation is spread over the northern part of the district and the greater part of Wychwood Forest, forming a tabulated surface intersected by narrow channel-like valleys,

* Memoirs of the Geological Survey, "Geology of the Country round Cheltenham," pp. 34, 35, *et seq.*

† This remarkable stratum has been so named by Dr. Wright, and is the "Cynocephala Zone" of Mr. Lycett, "Geology of the Cotteswold Hills."

‡ "Geology of the Country round Cheltenham," p. 23.

and sloping gradually towards the south at an angle of about 1°, nearly corresponding to the dip of the beds.

Though the term "Great Oolite" is here applied to the beds below the Forest Marble, yet the Forest Marble and Cornbrash can only be regarded as subdivisions of this formation, as they are, to a very large extent, connected together by community of organic remains, as well as by a general similarity in the strata themselves.

The Great Oolite may be divided into upper and lower zones, the latter of which includes the Stonesfield Slate, and it will be convenient to describe each of these zones separately.*

Lower Zone of Great Oolite—Stonesfield Slate.—This subdivision includes a variable series of strata, consisting principally of shelly oolite, sandy limestone, and laminated sandstones, splitting readily along the planes of bedding, and at Stonesfield producing the celebrated "slates" of that name.†

The subdivision attains its greatest dimensions along the western part of the district, and thins away towards the valley of the Cherwell, where it seems on the point of disappearing in a manner similar to the Inferior Oolite. This, however, is the case only with the *Lower Zone*.

At Sarsden there are several quarries, and from one of these, north of Castle Barn, the Earl of Ducie has obtained a specimen of the lower jaw, with teeth, of a Pterodactyle, which Professor Huxley considers, until further evidence, as belonging to *P. Rhamphorhynchus Bucklandi*.‡ From the same quarry bones of Saurian reptiles and fish remains have been extracted.

At Lyneham Barrow, near Sarsden, the beds of the lower zone are well shown in two quarries. They consist of white and yellow oolitic limestone, fissile where exposed to the air, and sometimes *false-bedded*. Many of the beds are composed of the *débris* of shells, while others are more compact. In the joints a soft white mineral occurs which is probably allied to Allophane. In a quarry on the west side of the Chipping Norton road at the head of Sarsden Valley the same beds are shown, but they are more regularly stratified. There are also quarries and road sections along the south side of the Evenlode valley, but everywhere the strata are of a similar character to those described. They attain a thickness of about 100 feet, and though they seldom prove good building stone here, yet the same beds at Tainton, near Burford, produce the best building stone in the country.§

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* The author adopted these terms in his description of the Great Oolite of the Cotteswold Hills, and they apply equally well in the Woodstock district. See "Geology of Cheltenham," p. 53.

† The term "Slate" is not used here in its geological acceptation, as it is properly applied only to slates which split along cleavage planes.

‡ See Professor Huxley "On *Rhamphorhynchus Bucklandi*, a Pterosaurian from the Stonesfield Slate," read before the Geological Society, March 23rd, 1859.

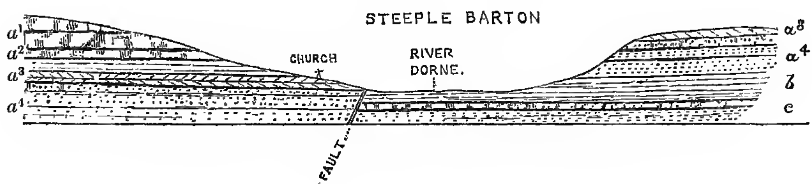
§ The oldest buildings in Oxford are of Tainton stone, which has stood well through several centuries. The same stone has also been used in the building of Blenheim Palace.

There are also good sections in the railway cuttings near Ashford Bridge and Westfield Farm; in the latter of which a coral band may be found about 10 feet from the ground. Similar shelly oolites compose the strata immediately above the bands which are worked for slate at Stonesfield.

Crossing over a considerable tract of country occupied principally by the upper zone of the Great Oolite, we reach the valley of the Dorne, and here find beds of yellow ferruginous sands passing upwards into calcareous sandstone at the base of the oolite, and resting on the Upper Lias clay. These are very well shown at Steeple Barton on the east side of the river, where they are 30 feet thick, and may be traced as far south as Linch Farm. The same beds are shown along the turnpike road east of Hopcrofts Holt, in the bank resting on Lias clay; also in the same road at Lower Heyford, and at North Brook Farm.

SECTION ACROSS THE DORNE, STEEPLE BARTON.

Fig. 2.



a¹	*Great Oolite, Upper Zone*	Thick-bedded white limestone.
a²	" "	Beds of shale and stony marl.
a³	*Great Oolite, Lower Zone* -	Slaty ferruginous sandstone.
a⁴	" "	Yellow sandstone and sands.
b.	Upper Lias clay -	Blue shales.
c.	Marlstone.	

The position of these sands, resting as they do on the Upper Lias clay at Barton and Heyford, and being apparently devoid of fossils, led me to consider them as representative of the Upper Lias sands of Gloucestershire, but my colleague, Mr. Polwhele, while surveying the Banbury district to the north, where these beds are very largely developed, came to the conclusion that they belong to the base or lower zone of the Great Oolite, a conclusion satisfactorily borne out by the evidence they afford of being intimately connected with that formation.

On both sides of the valley of the Cherwell these sandy beds are very thin, but they become largely developed northward in the adjoining district (Map 45, N.W.), towards Banbury. They are almost the only representative of the lower zone at the eastern part of the district, and where absent, as on the west side of the river south of Rowsham Farm, we only find 2 or 3 feet of sandy limestone, or shelly oolite, between the Upper Lias and the shaley beds of the upper zone. This may be clearly made out by means of the railway cutting and a quarry by the side of the lane which leads up the hill from Rowsham into the Oxford road.*

* At Northbrook Farm, Mr. Dashwood found specimens of a coral of the genus *Isastrea*, allied to *limitata*, according to Mr. Etheridge. It was found in a bed of clay while sinking a well. The specimen is in the Museum of Practical Geology.

The fossils of the zone (in this map) with the exception of the Stonesfield slate, are scarce, and generally in a fragmentary state, having evidently been drifted by the currents which produced the *false-bedding* so prevalent in the western side of the district.

Stonesfield Slate.—It is difficult in a short description like the present to do anything like justice to this formation, which, amongst palæontologists, takes high rank as having produced remains of almost every class of organized bodies, including Mammalia.* The present description must refer principally to the stratigraphical relations of these beds, and the list of fossils will give an idea of the extraordinary variety in the fauna of this subformation.

The Stonesfield slate series of this district may be regarded as a shallow-water condition of the base of the Great Oolite, as it is in several similar areas occurring at intervals throughout the whole range of the formation. We may instance the districts of Eyeford and Sevenhampton in the neighbouring Cotteswold Hills, which have also produced a similar terrestrial and comparatively shallow-water fauna.

The slate producing district is apparently included within a radius of half a mile round the village of Stonesfield, though it is uncertain whether equally good slates might not be found further towards the north and east.† Over a considerable portion south and west of the village the slate has been exhausted; and here, along the sides of the valley, vast heaps of broken slates and rubbish attest the antiquity of the workings. These beds have been used since the thirteenth century (perhaps earlier) for roofing; and, possibly, the broken ground, covered by natural turf and juniper bushes on the west side of the valley opposite Stonesfield, marks the spot of the earliest excavations.

The bed which is worked for slates is only one foot thick, sometimes less. It consists of a finely laminated, hard, calcareous sandstone. The upper and under surfaces are frequently more or less undulating or wedge-shaped, so that the same block does not yield slabs of equal size. The strata, for thirty-six feet above the slate bed, consist of laminated sandstones and sandy oolites with bands of shale, none of which are used. Above this there is a bed of marl which retains the water, and probably forms the base of the upper zone of the Great Oolite. The mines are perfectly dry, and are worked in galleries three feet high. The blocks are brought to the surface in early winter, and are exposed to the action of frosts, which causes them to split along the planes of bedding.‡

A good section of the Stonesfield slate series may be observed in the cutting of the lane which leads from the village to the

* *Amphitherium, Phascolotherium.*—Owen, Trans. Geol. Soc., 2nd series; Proceedings, vol. iii. See also Dr. Buckland, Trans. Geol. Soc., 2nd series, p. 390; Proc., vol. ii. p. 688; Ogilby, Proc. vol. iii.; Buckman and Brodie, Quart. Journ., vol. i.

† Workmen say, that on the east side of Bagg's Bottom the slate bed dies out.

‡ One of the pits by the side of the Woodstock road which I visited is 64 feet deep, and is worked with a horse-gin. The working of the slates is very expensive, and Welsh slates can be had cheaper, so that Stonesfield slate will probably only be used henceforth for its architectural effect.

banks of the Evenlode. The beds consist of flaggy oolitic limestone, sometimes sandy, with shale interstratified. The same beds may be observed by the river bank, resting on the Inferior Oolite.

The characteristic and most abundant fossil is *Trigonia impressa*, casts of which may be observed on almost every slab; also a small *Modiola*. Species of *Pecten*, *Avicula*, and *Ostrea* are also frequent, besides the rarer fossils given in the list below.

Fossils from the Stonefield Slate.

MAMMALIA.

Amphitherium Broderipii, Owen.
A. Prevostii, Cuv.
Phascolotherium Bucklandi, Brod.
Stereognathus ooliticus, Owen.

REPTILES.

Rhamphorhynchus Bucklandi, Goldf.
Megalosaurus Bucklandi, Meyer.

FISH.

Asteracanthus semisulcatus, Ag.
Acrodus leiodus, Ag.
Ganodus Bucklandi, Egert.
G. Colei, Buckl.
G. dentatus, Egert.
G. emarginatus, Egert.
G. falcatus, Egert.
G. neglectus, Egert.
G. Oweni, Buckl.
G. rugulosus, Egert.
Hybodus polyprion, Ag.
H. apicalis, Ag.
H. dorsalis, Ag.
H. grossiconus, Ag.
H. marginalis, Ag.
Pycnodus trigonus, Ag.
P. parvus, Ag.
P. rugulosus, Ag.
P. Bucklandi, Ag.
P. didymus, Ag.
P. Hughii, Ag.
P. latirostris, Ag.
Leptacanthus serratus, Ag.
L. semistriatus, Ag.
Pristacanthus securis, Ag.
Lepidotus tuberculatus, Ag.
L. unguiculatus, Ag.
Gyrodus perlatus, Ag.
Sauropsis mordax, Ag.
Scaphodus heteromorphus, Ag.
Strophodus tenuis, Ag.
S. favosus, Ag.
S. magnus, Ag.

MOLLUSCA.

Belemnites fusiformis, Park.
Nautilus Baberi, Lyc. & Mor.
Ammonites Hecticus.
Patella rugosa, Sow.
P. lata, Sow.
Pholadomya acuticosta, Sow.
Modiola Sowerbyana, D'Orb.
M. imbricata, Sow.
Trigonia impressa, Sow.
T. Moretoni, Lyc. & Mor.
T. costata, Sow.

INSECTS.

Elytra of Coleoptera.

PLANTS.

Thuytes expansus, Sternb.
T. articulatus, Sternb.
T. cupressiformis, Sternb.
T. divaricatus, Sternb.

Upper zone of Great Oolite.—This zone forms the principal mass of the Great Oolite in the district, and is composed of thick-bedded limestones, weathering white, resting on a base of clay or marl, with bands of stone. The limestones are frequently hard and compact, especially over parts of Wychwood Forest; and though always deep blue when reached at some depth, they weather white at or near the surface. We may therefore adopt the term "white limestone" as one which is generally applicable.

The strata of the upper zone present several points of contrast with those of the lower zone. In the first place, the stratification is generally regular, and we rarely find *false bedding*, which is so prevalent in the lower zone; secondly, in this area the limestones are not usually oolitic, but of a compact, or, where most fossiliferous, of a marly nature, as in the north-eastern part of the district; thirdly, though we frequently find only the moulds or casts, the fossils are seldom fragmentary, and appear to have been buried under the influence of still water. We find no stratigraphical evidence of those marginal and shallow-water conditions which so frequently mark the beds of the lower zone, and we cannot but infer a change from a shallow to a comparatively deeper sea at the commencement of this stage.

Commencing at the western side of the district, we find the white limestone composing a considerable portion of the ridge which forms the northern boundary of Wychwood Forest, overlooking the valley of the Evenlode. It may be seen in some quarries below High Lodge, where it is burnt for lime. There are also quarries along the road between Ranger's Lodge and Seafield. Near Witney there are several good sections, of which we may mention one by the Cheltenham road, above Minster Lovel, showing the superposition of the Forest Marble. There are also quarries, in a nearly similar stratigraphical position, by the roads to Crawley and Hailey. All over this district the character of the beds is the same, consisting of regularly bedded white limestones, with partings of marl and shale.

At the village of Bladon, near Woodstock, the beds of white limestone may be observed in some old quarries; and in the bank of the river Glyme, on the north side of Woodstock, a bed of dark carbonaceous clay occurs between two beds of marly limestone, and is a very constant feature over the district. It may be observed in the railway cutting at Kirklington station, where we have the following section, for which I am indebted to Professor Phillips:—

SECTION AT KIRKLINGTON STATION.

1. *Cornbrash* -	(Shown in quarries above the railway) -	8	0
2. Forest Marble	*a.* Pale clays and interrupted thin laminæ of shelly Forest Marble - - - -	12	0
3. Great Oolite -	*b.* Solid shelly oolite, top oolitic, middle close grained, base sandy - - -	3	9
	c. Sandy and marly bed - -	0	6
	d. Dark laminated clay, plants, jet, *Cyrena* - -	0	10
	e. Pale blue clay with calcareous nodules - - -	0	8
	f. Dark clay with plants, jet - - - -	0	8
	g. Pale blue and brown clay - - - -	1	5
	h. Sandy layer - - - -	0	6
	k. Oolite, pale, unequal grained, with waterworn top, sometimes drilled by Lithodomus; univalves, covered by drifted *Terebratula maxillata*, and *Ostrea crassa* -	2	4
	Thin parting.		
	l. Oolite, white, and of variable texture - -	2	6
	Thin parting.		
	m. Oolite full of *Terebratula maxillata* - -	3	0

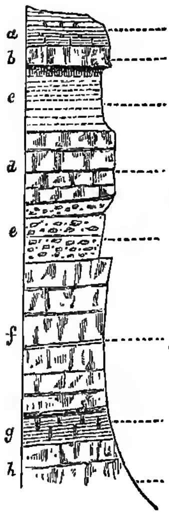
NOTE.—Professor Phillips considers the junction of the Great Oolite and Forest Marble as occurring at the base of the bed of clay with plants (*c*—*h*). This bed, however, is found over the district extending from Woodstock to Burford, underlying solid white limestone, which on the maps of the Geological Survey (Sheets 34, 44, 45 s.w.), has been adopted as the typical rock of the Great Oolite. This topmost bed is the "solid shelly oolite" (*b.*) of the above section, and is also shown at Enslow Bridge (Fig. 3) at Woodstock, and other places.

On the right bank of the river, in a semi-circular cliff, partly natural, we obtain the following section of the upper zone.

Fig. 3.

SECTION AT ENSLOW BRIDGE.

GREAT OOLITE—Upper Zone, Enslow Bridge.



		FT.
a.	Grey marl and marlstone - - -	4
b.	Hard, compact, grey limestone, with *Terebratula*, *Ostrea* - - - .. -	2
c.	Blue and greenish marl, with shaley bands, full of oysters and carbonized wood -	5
d.	White compact limestone, in thick beds, with *Cardium*, *Modiola*, *Lima*, &c. -	6
e.	*Terebratula bed*, made up almost exclusively of *Terebratula maxillata*, imbedded in marly limestone.	5
f.	White limestone, slightly oolitic, evenly bedded, and burnt for lime -	12
g.	Soft white fossiliferous marl - -	2½
h.	White limestone (base not visible).	

The most remarkable feature in this fine section is the bed (*e*), 5 feet thick, occupying a central position in the cliff, and made up almost entirely of *Terebratulæ*. They are in excellent preservation, and of all sizes.

At Tackley the basement beds of the upper zone, with *Ostrea Sowerbyi*, *Pecten annulatus*, *Panopea*, and *Rhynchonella*, consist of about 20 feet of shales and marls, which are succeeded by white limestone, all of which may be seen in the railway cuttings. The marls rest on the limestone bed of the lower zone, below which is a bed of sand, with water, resting on the clay of the Upper Lias. A similar succession may be seen in quarries at Berring's Wood, south of Over Kiddington.

In a quarry at Maiden Bower, above Rowsham, the beds appear to have a dip south-west at 5°, from what cause cannot be determined. The beds are very soft, and full of fossils, principally as casts. White limestones of a similar character form the higher grounds around Kiddington, Ditchley, and Stonesfield.

The shales and marls at the base of the upper zone may also be seen in a quarry in a fir wood by the road side, north of Tackley Wood. *Rhynchonella concinna*, *Terebratula*, *Pholadomya*, *Modiola*, and *Ostrea Sowerbyi* are plentiful here.

It has been already stated that the strata of the lower zone, which includes the Stonesfield Slate, gradually thins away from the west to the east of the district, so that along the valley of the

Cherwell, near Rowsham, the thickness is not greater than 10 feet, while at Sarsden and Wychwood Forest the thickness is little short of ten times that amount. But the case is different with the shales and white limestones of the upper zone; on their part we find no inclination to decrease in force in any direction.*

Fossils from the Great Oolite.

Teleosaurus, Enslow Bridge.
Belemnites, Hart Wood, Wootton.
Natica cincta, Phil., Enslow Bridge, Glympton.
Mytilus sublævis, Sow., Wootton.
Littorina, Stonesfield.
Turbo, Enslow Bridge.
Homomya, Wootton.
Pholadomya Heraultii, Ag., Woodstock, Enslow Bridge, Wootton, Glympton.
P. deltoidea, Sow., Wootton, Woodstock.
P. ambigua, Sow., Enslow Bridge.
Unicardium, Glympton, Enslow Bridge, Stonesfield.
Trigonia striata, Sow., Glympton.
T. costata, Sow., Enslow Bridge, Bladon.
Lima impressa, Lycet., Glympton, Enslow Bridge, Bladon.
Lithodomus, Glympton.
Modiola cuneata, Sow., Enslow Bridge, Stonesfield.
M. imbricata, Sow., Woodstock.
M. gibbosa, Sow., Enslow Bridge.
Lucina bellona, D'Orb., Enslow Bridge.
Isocardia, Wootton.
Gresslya, Wootton.
Panopœa, Wootton.
Myacites, Stonesfield.
Ostrea gregaria, Sow., Glympton, Enslow Bridge.
O. Sowerbyi, Lycet. and Mor., Woodstock, Tackley.
Avicula.
Tancredia axiniformis, Phil., Railway cutting, Stonesfield.
Ceromya Bajociana, D'Orb., Enslow Bridge.
Arca, Wootton, Enslow Bridge.
Astarte aliena, Phil., Enslow Bridge.
Pecten vagans, Sow., Enslow Bridge, Bladon.
P. fibrosus, Sow., Bladon.
Terebratula plicata, Buck., Woodstock.
T. maxillata, Sow., Glympton, Enslow Bridge, Wootton.
Rhynchonella concinna, Sow., Glympton, Enslow Bridge, Bladon.
Nucleolites, Enslow Bridge.
Clypeus Mülleri,† Wright, Stonesfield, Wootton, Enslow Bridge, Kiddington.
Acrosalenia spinosa, Ag., Bladon.
Thamnastrea Lyellii, M. Edw., Enslow Bridge.
Convexastrea Waltoni, M. Edw., Railway cutting, Stonesfield.
Isastrea limitata, Lamk., Railway cutting, Stonesfield.

Forest Marble.—This subformation of the Great Oolite derives its name from Wychwood Forest, of which it forms the greater portion. In its mineral character and fossils, it bears a strong

* It is an interesting fact in connexion with the constancy of this white limestone series, that upon crossing in a south-east direction towards Boulogne, the first district in which these formations are again brought to the surface the Great Oolite (probably the beds of the upper zone) is the oldest member of the oolitic series which has extended so far in that direction.

† This urchin, which is characteristic of the upper zone of the Great Oolite throughout Oxfordshire and Gloucestershire, is considered by Dr. Wright as distinct from *Clypeus solodurinus* (Agassiz), and has been named by him *C. Mülleri*, and is generally associated with *Echinobrissus Woodwardi.* See Wright, Monog. Palæon. Soc. 1857, p. 371.

resemblance to the lower zone of the Great Oolite. We find similar shelly oolitic limestones traversed by current planes, and similar beds of clay, and shale, and flagstones, with beds of oysters.

Owing to the rapid inclosure of Wychwood Forest, many quarries have been opened in Forest Marble, of which we may mention those of Leafield, Waterman's Lodge, White Oak Green, and Minster Lovel; and the following succession may be clearly made out.

The lower beds, which rest on the white limestone of the Great Oolite, consist of shelly oolite, much false-bedded, splitting into slabs and flags. They are composed principally of enormous quantities of broken oyster shells, with a smaller number of other shells, cemented by oolitic limestone. These beds are generally yellowish at the surface, but when reached at some depth are of the usual blue colour. They are quarried for wall stones and rough flags, and are about 30 feet thick.

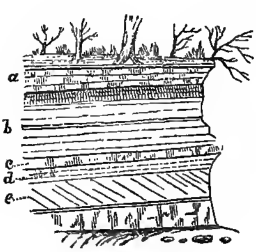
The higher beds consist of bluish clays and marls, with thin flagstones and roofing slates, for which they are quarried at White Oak Green. The surfaces of these flags are frequently marked with current ripples and worm tracks. Shells of *Ostrea, Pecten, Avicula,* fragmentary stems of *Pentacrinus,* and plates of *Echini* are not unfrequent. These beds vary from 20 to 30 feet in thickness.

Towards Witney the Forest Marble becomes very thin, and is represented by a bed of clay resting on 4 or 5 feet of slaty oolite. These beds of clay are very inconstant. For example, we find the Cornbrash resting on a thick bed of Forest Marble clay in the railway cutting west of Hanborough station; but in the quarry at East End, North Leigh, we find Cornbrash resting on coarse shelly oolite of the Forest Marble, without any intervening clay bands, the distance between being about 2 miles.

At Bladon there are very good sections of the Great Oolite, Forest marble, and Cornbrash, and the following may be observed at Bladon quarry:—

Section at Bladon Quarry.

Fig. 4.



		FT.	IN.
Cornbrash *a*	Rubbly, evenly bedded, shelly limestone, with *Terebratula obovata, T. perovalis, Myacites*	2	0
Forest Marble	*b* Regularly bedded shales and sandy flags	6	0
	c Hard bluish marly limestone weathering white	1	0
	d Bluish clay with *Ostrea*	1	6
	e Coarse shelly oolite, false-bedded, quarried for slabs and building	5	0
Great Oolite	*White limestone,* seen in quarries and sections at Bladon.		

In a quarry in Blenheim Park, opposite Old Woodstock, we find the following section:—

SECTION—BLENHEIM PARK.

		FT.	IN.
Cornbrash	Rubbly, shelly, cream coloured limestone, in two beds, with a parting of marl; *Terebratula obovota*, *Avicula echinata*, *Myacites*	5	0
Forest Marble	Parting of marl or slate	0	3
	Yellow, soft oolite, false-bedded	2	6
	Clays and flagstones, with broken shells, species of *Echini*, stems of *Pentacrinus*, *Pecten vagans*, *P. fibrosus*, *Rhynchonella concinna*	2	0
	Soft white oolite, false-bedded	10	0

Towards Tackley the Forest Marble becomes very thin, and above Enslow Bridge, on the west bank of the river, appears to have altogether died away. Here the Great Oolite reaches to the top of the cliff (see page 21), and immediately above, the Cornbrash may be observed in the road, so that there is actually no room for Forest Marble. On the opposite side of the river, however, a thick bed of clay, from which bricks are made, reappears, and from thence towards Stoney Middleton, where the Cornbrash runs out, we always find underneath the clay, 5 or 6 feet of shelly oolite, and clayey bands, belonging to the Forest Marble.

Cornbrash.—I have already, in describing the Forest Marble, given sections of this formation—the highest member of the Great Oolite. Although it seldom exceeds a thickness of 6 feet, yet is it one of the most persistent members of the oolitic series, and may always be easily recognized both by mineral character and enclosed fossils.

The Cornbrash may be described as a stratified rubbly cream-coloured limestone, breaking into thin beds with uneven surfaces. Each fragment has a coating of a deep reddish colour, which it imparts to the soil, and there are occasional thin partings of sandy marl, from which the fossils may be dislodged in a perfect state.

The Cornbrash, as its name implies, is well adapted to the growth of corn, and as a subsoil for wheat is superior to the other strata of the Great Oolite. This has been accounted for by Dr. Voelcker, who states, that the Cornbrash contains a larger percentage of phosphate of lime than the other members of the Lower Oolite, which is probably owing to the abundance of its fossils.

The stratification of the Cornbrash, though rubbly, is regular, and the fossils are generally well preserved, in both of which respects it forms a contrast to the Forest Marble. And here we have another illustration of a fact, which may be recognized throughout the oolitic series, whether as regards formations or individual strata, that those in which the bedding is most regular, and the fossils in best preservation, have a wider horizontal range than those in which these conditions are reversed. On the other hand, those formations in which we find false bedding prevalent, and the fossils generally fragmentary, have a more limited range in space, and of this the Forest Marble, the lower zone of the Great Oolite, and the freestone beds of the Inferior Oolite form examples.

The description given above applies equally well to this formation over every part of the district, and it will therefore only be necessary to mention where the principal sections occur.

At Norton Brize there are several good sections in quarries, and the beds may be seen resting on Forest Marble, which is worked for flagstones. There are frequent sections in the roads round Witney. At Hanborough station, and in a quarry by the road to Bladon, the Cornbrash is very fossiliferous, especially in *Terebratulæ*. There are several quarries between Bladon and Woodstock Road station, the Cornbrash being here used for road metal. There are also quarries by the road-side near Sturdy's Castle. On the east side of the Cherwell valley, sections may be seen in quarries at Kirklington station, at the south side of Kirklington Park; also along the road to Middleton, south of Slate Farm, where the rock is very full of fossils. Besides these there are the quarries at Bladon, and Blenheim Park, already noticed.

Fossils from the Cornbrash.

Ammonites (fragments), Witney, Norton Brize.
Myacites decurtata, Goldf., Sturdy's Castle, Woodstock, Norton Brize.
M. securiformis, Phil., Woodstock.
Trigonia striata, Sow., Woodstock.
T. costata, Sow., Woodstock, Witney, Norton Brize.
Pecten vagans, Sow., Sturdy's Castle, Norton Brize.
Pholadomya deltoidea, Sow., Witney, Sturdy's Castle, Woodstock.
Avicula echinata, Sow., Sturdy's Castle, Woodstock, Witney, Norton Brize.
Astarte aliena, Phil., Woodstock.
Modiola cuneata, Sow., Witney.
Lima rigida, Witney.
Ostrea gregaria, Sow., Norton Brize.
Arca (casts), Witney.
Unicardium (casts), Witney.
Rhynchonella concinna, Sow., Witney, &c.
Terebratula obovata, Sow., Sturdy's Castle, Woodstock, Witney, &c.
T. maxillata, Sow., Woodstock.
T. intermedia, Sow., Woodstock.
T. ornithocephala, Sow., Norton Brize.
Nucleolites Plottii (Klein), Witney.
N. clunicularis, Llhwyd., Woodstock, Sturdy's Castle.
Acrosalenia Wiltoni, Wright, Witney.

MIDDLE OOLITE.

Oxford Clay.—This great deposit, composed almost entirely of blue clay and shale, presents few points of interest in the Woodstock district. There are but few sections, and from these neither the Fossil-Collector or myself have been fortunate enough to obtain a single specimen.

It generally commences in the form of a low ridge of marshy ground rising above the flat surface of the Cornbrash, and of these ridges examples occur at Leafield, Ramsden Heath, Witney, Round Castle near Bladon, Tackley Heath, Kirklington, and Bletchingdon.

At Leafield and Ramsden Heath, the Oxford Clay forms outliers, which are capped by high-level quartzose gravel, and reach an elevation of about 500 feet. From these points commanding a wide range of country, the distant escarpments of the Chalk and Coral Rag may be distinctly traced for many miles. At Leafield, in sinking a well, crystals of selenite were found. Oxford Clay may be observed in some old pits on Hailey Common, but it is much mixed with Drift-gravel and sand. The next section is that near High Lodge, in Blenheim Park, where the clay is used for bricks and tiles, but though well searched no fossils were found. At Tackley Heath the clay appears to have been used for a similar purpose; as also on the north side of Kirklington Park.

The principal cause of the paucity of sections arises from the overspread of high and low-level gravels, which conceal the strata over a great extent of country.

The formation has been penetrated at Oxford and Wytham to a depth of 265 feet and 596 feet respectively.

Lower Calcareous Grit.

This formation occurs at Wytham Hill, and consists of a series of yellow sands and calcareous sandstones or grits, which are generally fossiliferous, and of variable thickness. It is the lowest member of the Coralline Oolite series.

The beds may be observed cropping out along the north flank of the escarpment below the Coral Rag, and also along the narrow neck which divides the two areas of this latter formation. There are, however, no good sections here, but the beds are better opened up at Cumner Hurst and at Headington Hill.

A second outlier occupies a small knoll south-east of Swinford Bridge, and is capped, apparently, by a few square yards of Coral Rag. In this place the Calcareous Grit appears to have lost considerably in thickness.

Coral Rag.

This formation rests on the Calcareous Grit just described, and caps Wytham Hill in two detached areas, attaining at the trigonometrical station an elevation of 583 feet above the sea.*

On the more southerly area there are few sections, as the formation is capped by a thick bed of high-level gravel; but on

* Text to Mr. Stackpoole's Geological Map.

the northerly portion above Wytham Wood, there are some old quarries and road sections.

The beds consist of unevenly bedded fossiliferous limestone or ragstone, composed principally of corals, shells of Mollusca, and Echinodermata, generally in a fragmentary state. The thickness of the beds is here considerable, but often appears greater than the reality. The following fossils have been collected from these strata:—*Lithodomus inclusus, Lima rudis, Ostrea gregaria, Thecosmilia annularis? Isastræa oblonga.* Spines and plates of *Cidaris*, and portions of *Serpulæ*, are common everywhere.*

Newer Pliocene Deposits.

The deposits belonging to this epoch in the Woodstock district may be arranged under two heads. The older "*high-level gravel*" belonging to the period of the Northern Drift; the "*low-level gravel*" being more recent.

The high level gravel consists principally of rounded quartz pebbles, but there also occur pebbles of flint, hornstone, and trap. The gravel is also accompanied by beds of yellow sand and bluish clay, the former generally presenting evidence of current action from the north. In this neighbourhood no fossils have been found in the high-level gravel.

All the higher ground and most prominent elevations are capped by this formation. Thus we find it on Wytham Hill, at a height of upwards of 500 feet, on Round Castle Hill, south of Bladon, on Leafield Barrow, Ramsden Heath, and the high ground formed of Oxford Clay at Kirklington and Bletchingdon. There is therefore, no doubt, that it once formed a continuous covering extending to all these points, but has subsequently been removed by denudation from those parts of the district which are below a certain level.

The connection of this gravel with the Northern Drift was first demonstrated by Dr. Buckland,† who traced the quartzose gravels of this neighbourhood to their sources in the New Red Sandstone and Carboniferous rocks of the midland counties, and the flints to the Chalk of Lincolnshire.

Low-level or Estuarine gravel.—These gravels differ from those already described in being composed principally of the detritus of the surrounding oolitic strata, and in occupying positions not exceeding 300 feet (or thereabouts) above the sea level. Elephant

* These fossils were determined on Cumner Hurst by Mr. Etheridge.
† Trans. Geol. Soc. vol. v. (old series); see also Prof. Phillips, Oxford Essays, 1855, Geology of Cheltenham, p. 90, *et seq.*

remains (probably those of the *Elephas primigenius*) are found very abundantly in this gravel.*

At Ascott, in the valley of the Evenlode, in excavating this gravel for the railway, the skeleton of a fossil elephant was discovered; and here the relative position of the older and newer gravels may be well observed, and has already been illustrated.† The difference of level between the quartzose gravel at Leafield Barrow, and the elephant gravel of the valley of the Evenlode at Ascott is about 250 feet. In the valley of the Windrush we meet this gravel again between Ducklington and Witney. At Hanborough we find it resting on the Cornbrash at an unusually high elevation. At Yarnton and Woodstock Road station good sections have been opened up in the gravel of this period, occupying elevations of about 240 feet above the sea. These beds are composed principally of Liassic and Oolitic pebbles, generally small and rounded. Waterworn oolitic fossils, as *Gryphaæ, Terebratulæ, Belemnites* are also to be found, but no shells belonging to the period at which the gravel was formed; the only representative of that epoch being fragments of elephant tusks. Besides fragments of local rocks, there are pebbles derived from the more ancient drift, such as quartz, flint, and hornstone, which have become re-embedded.

In the cutting of the railway near Combe, there is an interesting section, where we may see the beds of the Great Oolite worn into a channel which has afterwards been filled in by gravel of this period.

From the position of this gravel, which may be traced at intervals over the liassic and oolitic regions of Gloucester, Somerset, Wiltshire and Oxfordshire, and which is probably represented in the gravel of the Thames valley, we conclude that it was formed at a comparatively recent geological period, when the greater portion of the district was dry land, and the retiring sea extended into the heart of the country, filling the valleys, and forming a series of inland shallow *lochs* and straits. In Gloucestershire, this gravel contains marine shells. In Northamptonshire near Peterborough, in gravels which are in every respect similar, beds containing fresh-water shells are interstratified with others containing *Cardium edule*.‡ We may therefore suppose that these shallow inland lochs were liable to be disconnected from the sea, and formed occasionally fresh-water lakes.

Sarsen Stones.—These consist of large blocks of hard grit, which lie scattered at intervals over the district, but which cannot be referred to any of the surrounding formations. They may be seen along the northern flanks of Wychwood Forest, and in the

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* Dr. Falconer considers the *Elephas* (Euelephas) *antiquus* as belonging to an earlier period than the *E. primigenius*, which is of post Pliocene age. For more explanation upon this subject see Dr. Falconer's papers, Journ. Geo. Soc., vol. xiii., p. 307, and vol. xiv., p. 81; 1857.

† Geology of Cheltenham, p. 94.

‡ Prof. Morris, Lincolnshire Oolites, Quart. Journ. Geol. Soc., vol. ix.

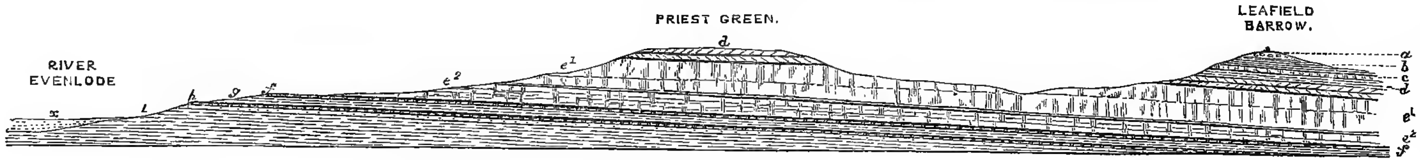
valley of the Evenlode near Ascott. These blocks increase in number and size towards the chalk downs of Wiltshire, and have been shown by Mr. Prestwich to be relics of an Eocene sandstone which from its extreme hardness has resisted the destructive agency of the sea during the denudation of the underlying formations. As this subject has been treated by Professor Ramsay in a former Memoir,* it will be unnecessary to enter into the subject more fully.

* Description accompanying Geological Map, Sheet 34.

Fig. 5.

SECTION FROM THE RIVER EVENLODE TO LEAFIELD BARROW,

Showing the general succession of formations from the Lower Lias to the Oxford Clay.



Horizontal scale, 3 inches to 1 mile. Vertical scale, 6 inches to 1 mile.

x. Low-level gravel.		
a. High-level gravel.		
b. Oxford Clay.		
c. Cornbrash	- - - -	6 feet.
d. Forest Marble	- - - -	50 „
e. e^1 Upper zone of Great Oolite	-	100 feet ?
e. e^2 Lower zone of Great Oolite	-	80 „ ?
f. Inferior Oolite	- - -	10 „
g. Upper Lias clay	- - -	10 „
h. Marlstone	- - -	20 „
l. Lower Lias.		

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75 NE. Part of Caernarvon, Merioneth, and Denbigh.
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75 SE. Part of Merioneth.
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